The unusual A-star VW Ari: chemical composition revisited

I.V. Chernyshova, S.M. Andrievsky, V.V. Kovtyukh and D.E. Mkrtichian

Department of Astronomy, Odessa State University, Shevchenko Park, 270014, Odessa, Ukraine

Abstract. Seven high-resolution and high S/N CCD spectra were used to derive elemental abundances in the atmosphere of VW Ari A (T_{eff}=7200, *log g*=3.7) which is the primary component of a visual binary system. The synthetic spectrum technique applied in the analysis allowed to reveal the following feature: the atmosphere of this star is strongly deficient in some metals, while light elements have solar-like abundances. Taking into account these results, one can suggest that VW Ari A is a λ Boo-type star. Another argument supporting this supposition is the following: on the diagrams "$(b-y)-c_1$", "$(b-y)-m_1$" and "$(b-y)-\beta$" (Paunzen et al. 1997) VW Ari A falls exactly in the region occupied by the λ Boo stars.

Note also, that a previous analysis (Andrievsky et al. 1995) has shown that the secondary component of VW Ari has a normal metallicity. Differences in chemical compositions of the two components appear to be due to the specific evolution of the primary VW Ari A.

Key words: Stars: individual: VW Ari – Stars: chemically peculiar

1. Introduction

VW Ari (HD 15165, BDS 1269) is a remarkable visual binary system consisting of two components: VW Ari A (V=6.^{m}71, A-type) and its companion (V=8.^{m}33, F-type). The primary VW Ari A is a multiperiodic pulsating star (probably of δ Sct-type) having non-radial modes. This star shows the spectrum typical of very metal-deficient stars. The rather high $v \sin i$ value found for this star, makes it difficult to derive accurate elemental abundances. A first attempt was undertaken by Andrievsky et al. (1995), who showed that calcium and iron are strongly deficient in the atmosphere of VW Ari A, while the secondary component possesses a solar-like chemical composition. Such a strange discrepancy between the metallicities of the two components can be explained by several hypotheses. For example, these stars possibly do not constitute a physical pair or, in case they do, such an unusual stellar system could be formed as a result of stellar capture.

Nevertheless, taking into account that 1) with a rather high probability VW Ari is a binary system and 2) the probability of stellar capture in the field is too small, we propose that the difference in chemical composition of both components could appear simply due to the peculiar evolution of VW Ari A as a λ Boo-type star.

The atmospheres of this type of stars are known to be strongly deficient in some heavy metals, while CNO-elements exhibit solar-like abundances (see e.g. Stürenburg, 1993).

To check this hypothesis, we performed a detailed spectroscopic analysis of VW Ari (primary component of the system) based on the spectral synthesis technique.

2. Observation

Seven CCD spectra have been obtained on 21 November 1994 with the échelle spectrometer LYNX (modified version: 29 spectral orders with the length of each order $\approx$ 60 Å) on the 6-m telescope (Special Astrophysical Observatory of the Russian Academy of Sciences, Russia, Northern Caucasus). The detailed description of the spectrometer is given by Panchuk et al. (1993). The resolving power was 24000, S/N $\approx$ 100. The spectral region was 5035-7185 Å. The epochs at mid-exposures were the following: JD 2449670+ 1) 8.158, 2) 8.165, 3) 8.186, 4) 8.215, 5) 8.232, 6) 8.247, 7) 8.263.

All spectra have been reduced using the DECH20 code (Galazutdinov, 1992), which includes extraction of spectra from images, dark and cosmic hits subtraction, flat-field correction, wavelength calibration, etc.

3. Atmospheric parameters

The effective temperature and gravity for VW Ari A (T_{eff}=7200 K, $log\ g$=3.7) were estimated using the photometric indices $(b-y) = 0.192$ and $c_1 = 0.801$, and the calibration by Kurucz (1991). We adopted a microturbulent velocity of 3 $\mathrm{km\,s^{-1}}$, which is appropriate for A-F main-sequence stars, and $v \sin i =$ 90 $\mathrm{km\,s^{-1}}$ was taken from Abt (1980).

4. Method and results of the analysis

The STARSP code (Tsymbal, 1996) was applied to derive the elemental abundances. The atmosphere model was interpolated from Kurucz's (1992) grid. The input oscillator strengths of the investigated lines and blends were initially corrected by comparison of the solar synthetic spectrum (solar model from Kurucz's grid, $V_t = 1$ $\mathrm{km\,s^{-1}}$ and solar abundances from Grevesse and Noels, 1993) with the solar flux spectrum (Kurucz et al. 1984). The resulting abundances were found by means of the optimal fitting of the synthetic spectrum to the observed one. They are given in Table 1.

Table 1. Abundances for VW Ari A

El.	C	O	Na	Mg	Si	S	Ca	Sc	Ti	Cr	Fe	Ni	Ba
[El/H]	0.0	-0.3	0.0	-1.5	-0.9	0.0	-1.0	-1.4	-0.50	-0.9	-1.6	-1.0	-0.8

5. Discussion

The abundance pattern in the atmosphere of VW Ari resembles that of λ Boo-type stars (see, e.g. Stürenburg, 1993, Andrievsky et al., 1998): normal abundances (or slight underabundances) of carbon and oxygen and strong deficiency of other elements.

An additional confirmation that VW Ari could be a λ Boo star is its position in $(b-y)-m_1-c_1-\beta$ diagrams. This star possesses photometric characteristics which place it exactly in the region occupied by λ Boo stars.

Supposing that VW Ari belongs to the λ Boo group, one can also easily explain the remarkable difference between the metallicities of this star and of its companion F-star with solar-like abundances (Andrievsky et al., 1995).

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